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Anomalous Suppression of Metalicity in YBCO/LCMO Superlattices Studied by Infrared Ellipsometry

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Beamline(s): U4IR, U10A

Introduction: The discovery of coexistence of superconductivity with magnetic order, including a ferromagnetic component, in $RuSr_2GdCu_2O_8$ (Ru-1212) [1] has spurred interest in how these two order parameters interact in this compound. To study this type of interaction, we have measured superlattices composed of $YBa_2Cu_3O_{7-\delta}$ (YBCO) and ferromagnetic $La_{0.67}Ca_{0.33}MnO_3$ (LCMO).

Methods and Materials: YBCO/LCMO superlattices were grown using laser ablation, and the in-plane far-infrared (FIR) dielectric response was measured spectral ellipsometry at the U4IR and U10A beamlines at NSLS [2]. Synchrotron light is essential for FIR ellipsometry due to its high collimation and brightness compared to conventional far-infrared light sources.

Results: As shown by the 10K data in Fig. 1, superlattices with a roughly 1:1 YBCO/LCMO ratio show remarkably suppressed conductivity (and corresponding real part) when compared to superlattices composed of primarily YBCO or LCMO, as well as that expected in the absence of any interaction between YBCO and LCMO. Detailed analysis of several superlattices indicates that the YBCO metallic (free carrier) response is strongly suppressed in the presence of LCMO over our entire temperature range (0-300K) even for 20nm thick YBCO layers. This behavior is strongly reminiscent of Ru-1212.

Conclusions: YBCO is strongly correlated to LCMO on a length scale of at least 10 nm, a length scale much larger than the correlation length (~2nm) of the superconducting state. This correlation exhibits itself through a stunning suppression of not only superconductivity, but also metalicity in YBCO. This has important implications in the light of recent experiments showing Josephson coupling in YBCO across an unexpectedly long distance of about 100nm [3] and theories involving unconventional electron-electron interaction in the normal state of YBCO, *i.e.* SO(5) theory [4].

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References:

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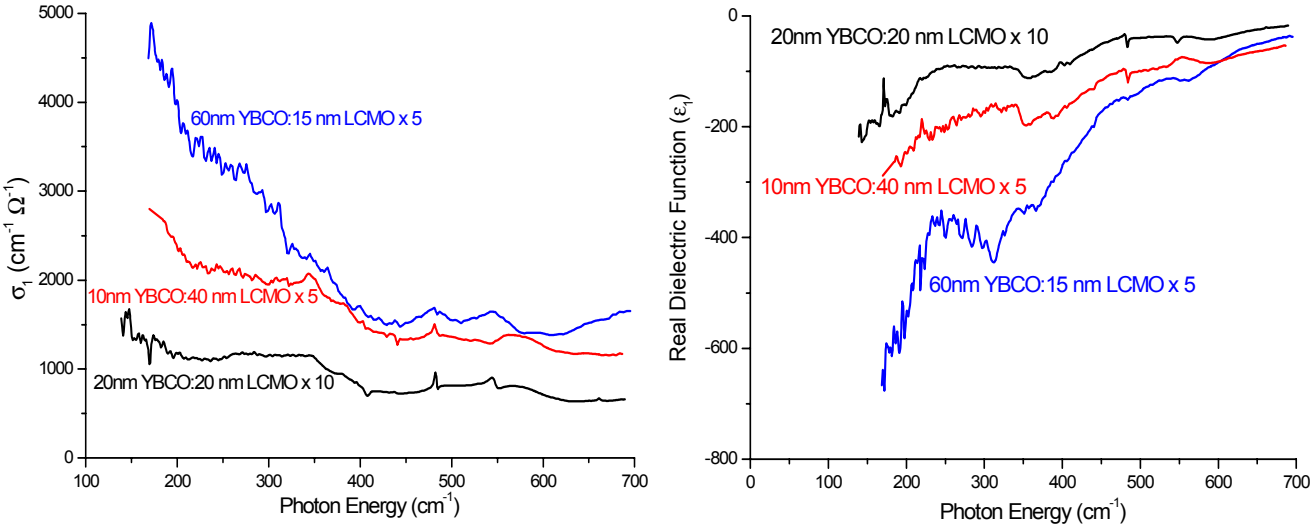

Fig. 1. Real conductivity and dielectric function for superlattices at T=10K. The superlattice with a 1:1 YBCO to LCMO ratio has lowered metalicity (free carrier response represented by a large positive σ_1 and large negative ε_1 at low frequency) compared to those comprised mostly of either YBCO or LCMO.